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CHINA REPORT
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APPLIED SCIENCES

REACTOR RECONSTRUCTION, RADIATION MONITORING REPORTED

Beijing YUANZINENG YANJIUSUO NIANBAO [ANNUAL REPORT OF THE INSTITUTE OF ATOMIC ENERGY RESEARCH] in Chinese Aug 80, annotation and pp 154-163, 207, 216

[Annual report sections on reconstruction of heavy water reactor and radiation monitoring; figures and tables renumbered]

[Text] This yearbook gives a comprehensive introduction to the work by the Institute of Atomic Energy Research in 1979 (1 January through 31 December), including: important progress in nuclear physics, nuclear data and nuclear technology applications, accelerators, nuclear electronics and instrumentation, computers and computer science, radiochemistry, radiochemical engineering, reactor science and engineering, radioisotope production, separation of stable isotopes, treatment of radioactive wastes, environmental production and radiation protection; the maintenance and improvement of important equipment; production procedures; learned activities; and international interchange. In addition, it gives a list of articles published in journals.

This annual report is intended for reference by scientific and technical personnel involved in nuclear scientific and technical research or applications research and by instructors and students in advanced schools.

1. Main Design Aspects of Reconstruction of the Heavy Water Reactor

1.1 Physical Design

In order to increase the thermal neutron flux per unit power output in the experimental channels, to increase the irradiation space in the inner vessel of the reactor and to suitably increase the reactor's reserve reflectivity, a physical design for reconstructing the reactor was developed.

We continue to use low-enrichment uranium and the existing types of fuel elements, so as not to increase the operating costs of the reconstructed reactor.

We compared approaches using a tight lattice and a loose lattice, both with low-enrichment uranium, in addition to considering the possibility of reengineering the reactor. Four-group one-dimensional and two-dimensional programs were used for a rather large number of theoretical calculations and for selected comparisons. The ^{235}U enrichment was varied from 2 to 5 percent, and square lattices with spacings of 18, 13, 12, 10, 9.2, 9.0 and 8.0 cm and an equilateral triangular

lattice with a spacing of 10 cm were considered. The effect of central reflecting well dimensions on the peak heat flux value and reflectivity was calculated. The effect of the number and position of control rods and vertical channels was computed. We computed isotope target reflectivities and flux attenuation factors. In addition, a one-dimensional burnup program was used for burnup calculations, and fuel cycle formulas were studied (in addition, a two-dimensional program is now being run).

The same programs and numerical values were used to compute the zero-energy real charge and its distribution so that the computation results could be compared with actual zero-energy data.

The reactor reconstruction approach that was finally chosen was a low-enrichment uranium tight-lattice neutron-well design. The ^{235}U enrichment was 3 percent. The spacing of the square lattice was 9.2 cm; the core height was 101 cm, the equivalent inner radius was 15.57 cm and the equivalent outer radius 46.7 cm. A cross section of the core is shown in Figure 1.

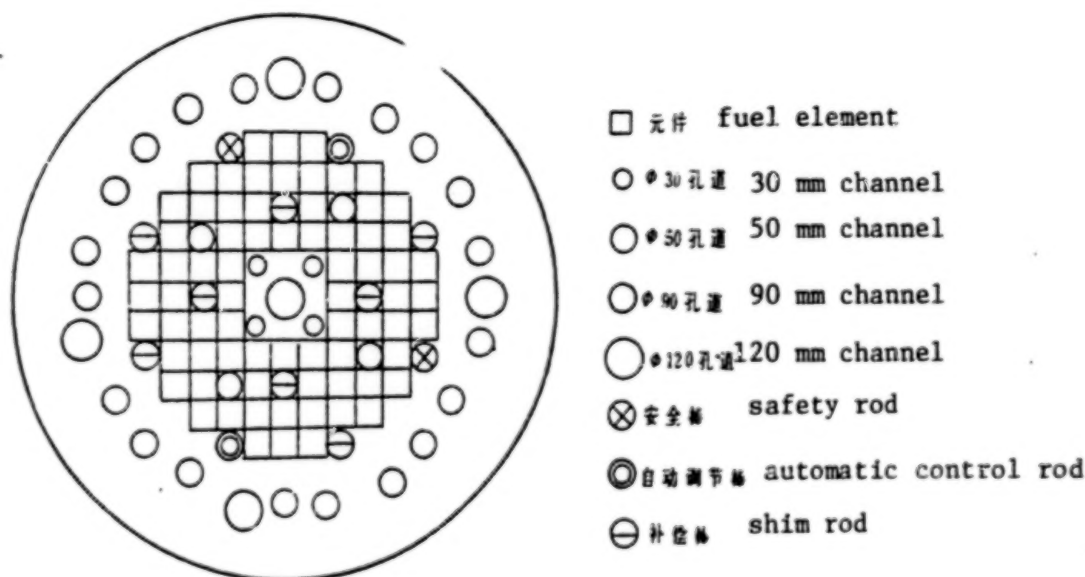


Figure 1. Core layout of the heavy water reactor.

This approach increases the maximum neutron flux per unit power by 50 percent over the value in the unreconstructed reactor, increases the irradiation space inside the reactor by 2.6 times, and increases reserve reflectivity by 3 percent; all of these improvements are favorable for comprehensive utilization.

The zero-energy experimental results indicate that the calculation method and constants used were applicable to the low-enrichment uranium heavy-water reactor lattice and that the computation results are reliable.

(by Cao Yizheng [2580 1355 6927])

1.2 Hydraulic and Thermodynamic Design

The program of hydraulic and thermodynamic improvements primarily involved exploitation of latent capabilities, but also entailed modernization and improvement of some equipment and system piping. The main points are as follows:

A. Primary water system: (1) The original system, in which two pumps were in operation and one was used for backup, was replaced by simultaneous operation of three pumps so as to increase total coolant circulation, but because the circuit resistance was too large, this produced only a limited improvement, and accordingly it was necessary to make changes in the circuit.

(2) Valve No 1 was eliminated, and the 98 mm diameter reactor outlet pipe was replaced by a 128 mm pipe, which was connected to the suction intake of pump C.

(3) The heat exchanger was modernized, the number of parallel tubes was increased from 253 to 447, the heat exchange surface was increased and the flow resistance was lowered.

(4) The hydraulic resistance components in the main reactor intake pipe were removed.

(5) The original flow diaphragm was replaced by a low-resistance diaphragm.

(6) The bypass piping was eliminated.

After these steps were taken, the total coolant flow was $583 \text{ m}^3/\text{hr}$ when the three heavy-water pumps were operating at 3,000 rpm.

B. Secondary Circuit

(1) The original system of operating two pumps and keeping a third for backup was replaced by operation of three pumps with one in reserve.

(2) The Venturi tube and main flow diaphragm were removed.

After these steps had been taken, the flow capacity of the secondary circuit was $1,800 \text{ m}^3/\text{hr}$.

Once the benefits of these changes had been realized, thermodynamic calculations were made for the entire system.

(1) Cooling tower heat diffusion computations: it was concluded that under summer conditions in the Beijing area, when the reactor power was 15 MW the temperature of the secondary circuit water leaving the cooling tower should not exceed 30°C .

(2) Heat exchanger computations: when the reactor power is 15 MW and the secondary circuit flow rate is $1,800 \text{ m}^3/\text{hr}$ and the water temperature was 32°C , the water in the primary circuit should not exceed 50°C after cooling.

(3) Fuel element cooling computations.

Computation results for several regimes are shown in Table 1.

On the basis of our results we believe that the power of the reconstructed heavy-water reactor will be 15 MW.

(by Huang Daoli [7806 6670 4539])

1.3 Improvement of Process Channel Design

Long-term operation indicated that the structure of the original process channels was too complex, with a rather sealing points, and assembly was difficult, in addition to which there was frequent helium gas leakage during operation. Reconstruction of the reactor required a decrease in the lattice spacing from 130 to

Table 1. Results of Thermodynamic and Hydraulic Computations

	Before Recon- struction	After reconstruction		
		clean reactor	control rods fully inserted	isotopes fully loaded
Total coolant circulation, m ³ /hr	400	582	582	582
Flow rate per rod, m ³ /hr	6.27	10.4	10.4	10.4
Maximum flow speed over element surface, m/sec	3.61	6	6	6
Maximum power per rod, kW	170	305	305	305
Maximum fuel element wall temperature, °C	107	123.8	123.8	123.8
Maximum thermal load, 10 ⁶ cal/m ² -hr	0.842	1.69	1.69	1.69
Radial power inhomogeneity coefficient	1.38	1.33	1.43	1.46
Total reactor power, kW	10350	16550	15400	15100

92 mm, but the heads of the original process channels would then be too large and could not be accommodated by the reactor cover. The improved design had the following technical specifications:

- A. The maximum diameter of the tops of the process channels was decreased from 85 mm to 78 mm so that they could be easily installed and temperature sensor cables could be passed down between them.
- B. The heights of the convex aluminum stoppers at the tops of the process channels were decreased from 315 to 128 mm, resulting in a more open reactor top structure in which it was easier to perform decontamination and special operations.
- C. The number of sealing points was decreased from four to two.

D. The total number of parts was decreased from 48 to 38, lessening the quantity of raw materials used and the amount of machining needed, and making assembly more convenient.

The following tests were conducted on the process channels after the improvements were made:

- A. Flush test of entire process channel.
- B. Vibration tests of channels.
- C. Tests of hydraulic characteristics.

These tests indicated that the improved process channels met reactor process requirements.

(by Huang Daoli)

1.4 Design Improvements on Automatic Control Rods

It could be inferred from the control rod temperature measurement curves that if there was a helium leak in the control rod guide tubes while the reactor was operating at 15 MW, the temperature of the absorbers (cadmium elements) might reach 800° C. This indicated that continued use of the original control rods after reconstruction would be dangerous.

The design of the control rods was improved, and the helium coolant in their guide tubes was replaced with D₂O, using natural cooling.

Experiments on the operating characteristics of the automatic control rods (original design) in water and nitrogen [helium] indicated that: (1) they could attain a maximum descent speed of 500 mm/sec in either water or helium; (2) there were clear differences between the automatic control rod transition curves in water and in helium; (3) when descending in water, the steel cables attached to the tops of the rods would not curve, so that maneuverability was improved. Clearly, a changeover to operation of the control rods in water met requirements.

An inner tube was added at the center of the new control rods, and the cadmium elements were mounted in the space between the inner and outer tubes, which was filled with helium. This control rod design not only decreased the resistance when they were operated in water, but also made possible two-surface cooling and decreased the rod temperature. The new design is shown in Figure 2. The rods were manufactured by this institute's plant.

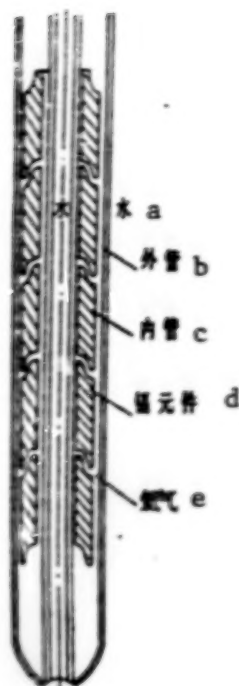


Figure 2. Design of new control rods.

Key:

- a. Water
- b. Outer tube
- c. Inner tube
- d. Cadmium element
- e. Helium

(by Liu Hanzhen [0491 3352 4394] and
Li Xiuqing [2621 4423 3237])

1.5 Design Changes in the Reactor Inner Vessel

The inner vessel is a major piece of core equipment. LP21 aluminum alloy was used in the design of a reactor inner vessel which met the reconstruction requirements (see Figure 1); sheets and forgings of this alloy were subjected to comprehensive tests which indicated that the chemical composition was in accordance with standard YBT1-63 and the mechanical properties were in accordance with standard YBT4-63, so that design requirements were met. The requirements for the weakest point on the pressure chamber cover were: $\sigma_{\perp} = 21-24 \text{ kg/mm}^2$, $\sigma_{\parallel} = 11-15 \text{ kg/mm}^2$. No inter-crystalline corrosion was found, but various degrees of pitting were found on the forgings; ultrasonic defect testing of the forgings did not detect any defects equivalent to Φ_2 or greater.

X-ray tests were made on all welds; 76 percent of them met design requirements, while 24 percent basically met the standards for JB1580-75 class I welds and could be used without repair.

The weld strength was required to be greater than 12 kg/mm^2 and the cylinders were 8 mm thick; strength calculations indicated that these specifications would be adequate.

In order to compensate temperature changes, there was an extensible joint between the upper and lower cylindrical sections of the vessel, of essentially the same shape as in the original vessel. We determined the strength according to the somewhat conservative Kellogg formula and concluded that it was safe. The design also called for fatigue simulation tests. Based on a utilization period of 20 years, and allowing for a fatigue safety factor of 20, a total of 20,000 cycles was required; the test results showed that the joint was whole and undamaged after 23,000 cycles.

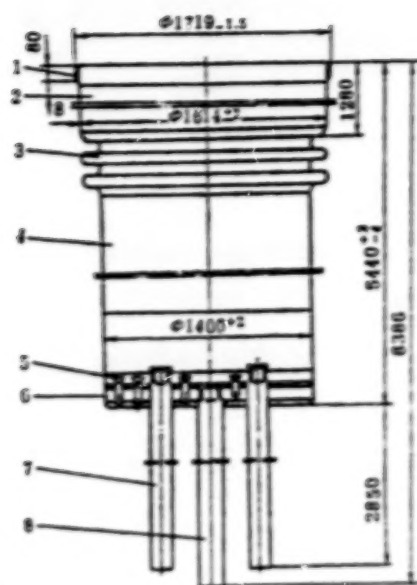


Figure 3. Inner vessel of reactor.

Key:

1. Upper flange
2. Upper cylinder
3. Extensible joint
4. Lower cylinder
5. Cup pieces
6. Pressure chamber
7. Water outlet pipe
8. Water intake pipe

In order to adapt to a heavy-water flow rate of $500 \text{ m}^3/\text{hr}$, the height of the pressure chamber water cavity was increased from 50 to 70 mm, and the design provided for 116 cup-shaped pieces on the cover plate, to which the process channels, vertical experimental channels and control rod guide channels would be attached.

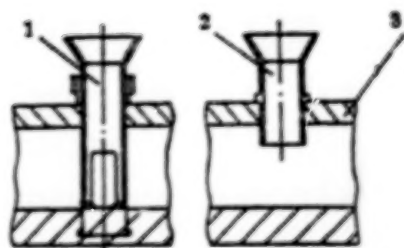


Figure 4. Structure of cup pieces on pressure chamber.

Key:

1. Load-bearing cup piece
2. Cup piece
3. Pressure chamber cover plate

Following strength tests of the cover plate, the number of load-bearing cup pieces (see Figure 4) connecting the cover plate to the pressure chamber was increased from 64 to 84. All cup pieces were fixed to the cover plate with expansion joints. Multiple tests gave the expansion value (expressed as the rate of decrease in wall thickness $Wt\%$) which produced optimum expansion joint strength and sufficient gas tightness. The expansion joint strength was greatest when $Wt\%$ was 5 percent (see Figure 5).

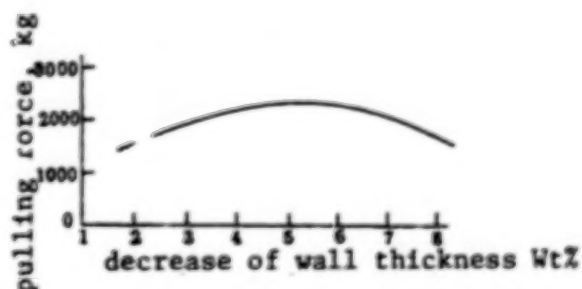


Figure 5. Relationship between pulling force and change of thickness for LT21CZ alloy.

(by Gao Jintang [7559 6930 1016] and
Li Yanshui [2621 1750 3055])

1.6 Design Improvements on the Main Heat Exchangers

We have designed and fabricated two horizontal tube-and-shell heat exchangers.

The two ends of the outer shell were assembled with hexagonal welds and welded to the tube plate with circular outer welds. The inner shells are fully expansion-joined and argon arc welded to the tube plate. With the exception of two fresh water cavities made of carbon steel, the rest of the unit is made of 1Cr18Ni9Ti stainless steel.

The heat exchanger cooling surface has been increased from 58 m^2 to 102 m^2 , and the outer dimensions have been increased by only 15 percent, making it possible to meet fully the requirement that it be installed in the original process room.

The first of the main heat exchangers was flush tested off-loop and achieved the required characteristics in a vacuum leak test: the total leakage was 3.14×10^{-6} torr-l/sec. The second unit is now being tested.

(by Yuan Shuiquan [5913 3055 2164] and
Li Yanshui)

1.7 Design of the Main: Reactor Shielding

We used a one-dimensional 31-group shift diffusion formula for neutron calculations and a point-source attenuation model to compute an infinite uniform medium Taylor buildup coefficient, which was used to calculate the gamma ray figure by the multilayer flat plate integral method. The calculation results showed that the main shielding would be adequate following reconstruction. If the radial water tank should lose water, the total dose rate would increase by 5.5 times and the neutron dose rate by 560 times; but because the neutron dose rate is only 3 percent of the total dose, the problem is still primarily that of gamma ray protection. The calculated neutron dose at the surface of the reactor after loss of water by the water tank would be within the permitted range. The shield water tank acts primarily as a thermal screen, but loss of water would increase the heating rate of the heavy concrete biological shield by a factor of 10, and the heat conducting effect of the water in the inner layer would be lost, so that an excessive temperature buildup in the heavy concrete would be the main unfavorable consequence of loss of water by the water tank. The ray method was used to estimate the neutron and gamma ray dose in the horizontal experimental channel: the calculated values were in general agreement with measurements.

(by Zhu Huannan [2612 3562 0589])

1.8 Improvement of the Air Purification System

The original exhaust system had no exhaust air purification equipment; three new exhaust units with three exhaust filter chambers have now been installed. Each of the chambers has two filter units in series. The first unit has six high-efficiency glass fiber filters which eliminate at least 99.91 percent of particles measuring 0.3 microns or larger. The second unit has eight activated charcoal filters which eliminate iodine vapor released during a reactor emergency.

The activated charcoal bed is a newly-designed model F filter unit whose main characteristics are given in the table below.

Xinhuo No 8 charcoal is being used temporarily. The metal structural components of the filter are ordinary carbon steel. The charcoal is packed manually, then subjected to spot testing by the impact method. The charcoal filter nets are made of two different materials: one is GG 40-42 mesh silk gauze and the other is #078 24-mesh stainless steel screen.

The high-efficiency filter and activated charcoal filter are installed in steel brackets in the filter channel of the air chamber and can be installed or replaced individually.

During reconstruction of the reactor, the blower system was also improved, the Soviet-made Lieke [phonetic] metal net wet-stator oil type electrically-powered filter unit was replaced by an MI foam plastic filter, a water-type heater was replaced by a steam heater, and the relevant heat supply piping was modernized; the blower was reconditioned in 1979, producing a great improvement in air purity in the facility.

Table 2. Main Parameters of the Model F Filter

Characteristic	Value
Filter surface, m^2	0.468
Air flow, m^3/hr	500
Surface speed, m/min	14.4
Specific flow rate, liters/ $cm^2 \cdot min$	0.9
Thickness of activated charcoal layer, mm	58
Charcoal layer resistance, $mm H_2O$	18.27
Structure resistance, H_2O	16
Weight of iodine remover, kg	55
Installed weight of activated charcoal, kg	20

(by Yuan Shuiquan)

1.9 Initial Estimates for the Production of Trans-Plutonium Elements for Research Use

Reconstruction of the heavy water more than doubled the neutron flux and energy spectrum parameters. We have made estimates of the capability for producing trans-plutonium elements for research, assuming various irradiation targets and irradiation regimes. On the basis of accumulation laws for different nuclides in chain reactions, exchanging various irradiation targets between the central channel and the reactor channels at suitable times so as to make alternating use of high thermal neutron flux and high resonance neutron flux makes it possible to increase the yield of ^{252}Cf , the ultimate product, by 25 to 70 percent. The main calculation results are:

A. Irradiation of 1 g of ^{241}Am for 400 days will yield 0.01 g each of ^{243}Am and ^{244}Cm ;

B. Irradiation of 1 g each of ^{243}Am and ^{244}Cm for 600 days will yield 0.1 mcg of ^{252}Cf ;

C. For irradiation of ^{241}Am to produce ^{242}Am , it is best to use a channel with high resonance neutron flux; if 1 g of ^{241}Am is irradiated in a core channel, a maximum quantity of 0.757×10^{-2} g of ^{242}Am will be obtained after 40 days;

D. In irradiating ^{241}Am to produce ^{242}Cm and ^{244}Cm , it is best to use the channels with high thermal neutron flux. If 1 g of ^{241}Am is irradiated in the central channel, a maximum of 0.4 g of ^{242}Cm will be obtained after 140 days; irradiation for 400 days will produce 0.01 g of ^{244}Cm , 0.1 mg of ^{245}Cm , 0.07 mg of ^{246}Cm , 0.3 mcg of ^{247}Cm and 0.2 mcg of ^{248}Cm ;

E. Irradiation of 1 g of ^{242}Pu for 100 days will produce: 0.17 g of ^{243}Am , 0.06 g of ^{244}Cm , 0.55 mg of ^{245}Cm , 0.37 mg of ^{246}Cm , and 0.3×10^{-10} g of ^{252}Cf .

2. Replacement of the Inner Vessel of the Heavy Water Reactor

2.1 Summary

The following factors were taken into account in the decision to lift out the entire inner vessel of the reactor: (1) whether 20 years' neutron irradiation of the blocks in the graphite reflective foundation in which the inner vessel was installed had caused sufficient change in their dimensions to wedge the inner vessel in place; (2) whether the inner vessel still had sufficient mechanical strength and a sufficient percentage elongation value after 20 years' operation; (3) whether the traveling crane in the reactor room had sufficient hoisting height; (4) whether remote control would be sufficiently reliable in the hoisting out the highly radioactive vessel; (5) whether it would be possible to bury the vessel in a burial shaft in the northern part of the reactor room and store it there for a long period.

Disassembly of the reactor included: (1) lifting all uranium rods, control rods, temperature measuring instruments, water level instruments and experimental channels out of the inner vessel and using a deep-well eccentric pipe cutting tool to cut off all channels which were pinched shut; (2) removing the fan-shaped water tank from the top of the reactor and removing the annular water tank; (3) removing the large sealing flanges between the aluminum protective cap and the inner vessel and between the inner and outer vessels; (4) hoisting out the aluminum protective cover by remote control and automatically inclosing it in a protective cover; (5) after a preliminary raising of the vessel, hoisting it out by remote control and inclosing it in a protective cover, using a television system to monitor its transport to the burial pit; (6) replacing the aluminum cover on the vessel and sealing both in the same pit for long-term storage.

Spot checks were made of four experimental channels in the graphite reflector, and an underwater television system was used to make a macroscopic examination of the inner vessel. No abnormal deformation was found, proving that the theoretical analysis of dimensional changes produced in the graphite reflector was reliable.

In order to hoist out the inner vessel safely and reliably under remote control, we carried out a complete simulated trial run. The inner vessel used in the trial

run had the same dimensions and shape as the actual vessel. The trial run was used to train personnel and to make a final determination of the positional coordinates of the vessel.

The necessary strength calculations were made for all hoisting equipment and cables, and load tests were performed; a safety factor of 10 was used.

Before the inner vessel was hoisted, an inspection and adjustment of the critical hoisting equipment, namely the overhead traveling crane, was made in order to assure normal operation.

A correct evaluation of radiation dose levels in the work area and in the disassembly equipment during disassembly of the reactor was of great importance for deciding on the hoisting procedure shielding measures for work at the site, and work schedules; special consideration was devoted to radioactive dust from the vessel and the aluminum protective cover. A protective cover in which the vessel and its cover could be automatically enclosed so as to prevent the diffusion of radioactive dust was specially designed and manufactured. After comprehensive preparations had been made, the reactor vessel, which had been in operation for 20 years, was successfully hoisted out on 5 June 1979 and buried in the burial shaft.

A dynamic analysis was made of the condition of the new reactor vessel in the horizontal and vertical position. This analysis showed that during suspension it was not necessary to use elaborate reinforcement measures, which simplified the installation process.

In order to assure safety, correctness and reliability in the installation of the new vessel in the highly radioactive area, a specially designed and manufactured contact sensor was installed at the ends of two of the inner vessel's water outlet pipes; these, together with other positioning measures, assured that the new vessel would be correctly lowered into the graphite reflector foundations, and on 28 December 1979 the new vessel was safely placed in the reactor.

Currently various types of installation and adjustment work are under way following the placement of the vessel. It is expected that all of the work involved in replacing the inner vessel will be completed within the first half of 1980.

(by Li Yulun [2621 3768 0178])

2.2 Analysis of the Irradiation Characteristics of the Graphite Reflector

The main factors affecting the irradiation dimension changes of the graphite blocks are: the irradiation temperature, the integral fast neutron flux ($E > 0.18$ MeV), the composition of the blocks, the production process used, and the orientation of the blocks in the reactor (pressed graphite has pronounced anisotropy). Measurements of the electrical resistivity of the blocks in different directions was used to determine their orientation in the reflector. A statistical analysis was made of the 20 years' operating history of the reactor. The actual graphite layer temperature values were used to determine the radial temperature distribution in the graphite reflector, and as an approximation, the actual radial neutron

Flux distribution was used in place of the temperature distribution, except that the measured temperature value was used for the highest point. The total amount of energy released during 20 years of operation of the reactor, the results of a two-dimensional four-group reactor physical computations and one-dimensional three-group shield calculations, and the measured nickel flux and thermal flux were used to determine the integral fast neutron flux corresponding to the calculated irradiation dimension changes. The computed results indicated that the dimensional change of the graphite reflector resulting from irradiation was not large and would not cause the inner vessel to become wedged in it. Observations made in the channels in the graphite reflector revealed no abnormal deformation. Observations of the inner surface of the inner vessel also failed to show pressure-induced deformations resulting from swelling of the graphite during irradiation. Finally, after the inner vessel had been hoisted out of the reactor, a visual determination of the condition of the graphite layer was made; this confirmed the conclusions based on analysis and calculations. The photograph shows the condition of the graphite reflector foundation after the inner vessel was moved.



Figure 6. Condition of the graphite reflector layer after removal of the inner vessel.

In addition, after analysis of the latent energy in the graphite layer it was concluded that it did not present a serious problem, and that provided no high-temperature operations were carried out in its vicinity there would be no release of latent energy. An analysis of the strength and oxygen resistance of the blocks concluded that both characteristics were excellent.

2.3 Design Considerations for the Inner Vessel Burial Pit

A new inner vessel burial pit was dug in the northern part of the reactor room. It was designed as a vertical shaft 9.5 meters deep with an upper diameter of 1.8 m and a lower diameter of 0.8 m. The upper dimension was chosen so as to provide room for the vessel to be inserted into the shaft while suspended. The shaft was surrounded by a concrete screen and had a stainless steel inner liner to prevent entry of subsurface water. The top was provided with a steel cover, a rubber gasket and a cement cover slab, which were level with the reactor room floor so as not to decrease the operating area in the room. External radiation was at the

background level. The pit was provided with ventilation and with seepage detectors, and after the vessel was inserted the top was sealed and the air pipe cut off to prevent gas diffusion. In addition to the old vessel, the highly radioactive aluminum cap 3.2 m high and 1.7 m across was buried in the pit.

During design of the earth works, full account was taken of the plan location of the pit, the strength of the foundation soil, and engineering safety. A location where the existing foundations would not be affected was chosen, and the open caisson method used. Such geological characteristics as the subsurface water table were determined to assure that the work would proceed smoothly.

(by Tao Qingcheng [7118 3237 3397] and
Gu Chuanbing [6253 1557 0365])

2.4 Examination of the Inner Vessel

An underwater television system was used to inspect the old vessel. After the heavy water was exhausted from the vessel it was filled with light water as a shield. A special underwater television frame was designed. The television camera unit could be moved in three dimensions in the water-filled vessel. Particular attention was devoted to observing the welds in the vessel, the heavy water-helium boundary line, and corrosion in the pressure chamber cup pieces and other components. It was concluded that the corrosion was not serious; the inner surface of the vessel in the core section showed no abnormal deformation; the vessel strength calculations and analysis were reliable; and it was judged to be feasible to hoist the entire unit out.

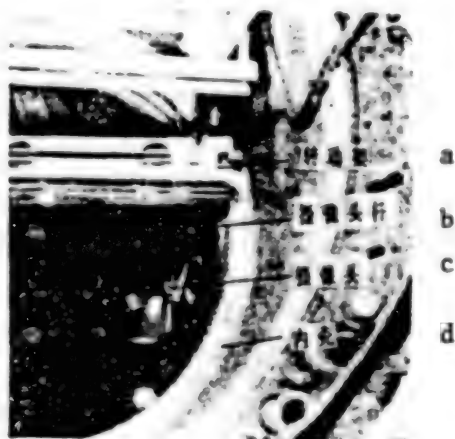


Figure 7. Inspection of the old vessel.

Key:

- a. Rotating framework
- b. Camera rod
- c. Camera
- d. Inner vessel

(by Chen Rongfan [7115 2837 3058])

2.5 Equipment for Raising the Vessel

Before the vessel was hoisted out, in order to make a final determination as to whether it was jammed or wedged, equipment for raising it was designed and produced. It consisted of an I-beam, an electric weighing scale, a hoisting jack, cables and tackle, and a protective water tank. The entire weight was supported by the annular water tank around the reactor. The horizontality of the hoisting equipment

could be controlled to within 0.2 mm, and the vessel could be raised 150 mm. The electrical scale continually displayed the weight of the inner vessel and fixtures so as to make it possible to determine at any time whether the vessel was jammed or wedged or whether any other trouble had occurred.

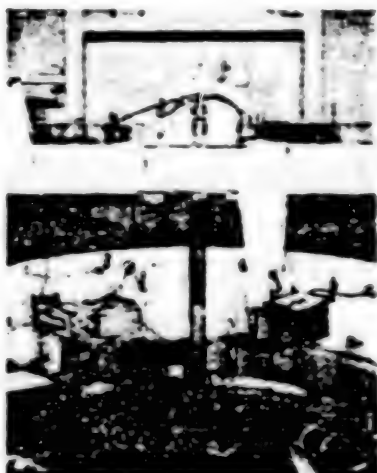


Figure 8. The equipment for raising the vessel.

(by Kang Yalun [1660 0068 0243] and
Gu Chuanbing)

2.6 The Protective Covers for the Vessel and Aluminum Cap

In order to prevent the scattering of radioactive dust during the hoisting of the old vessel and cap, a protective cover was designed and manufactured. This consisted of a guard ring, a fastening bolt, an elastic rubber ring, and white silk fabric, which were installed on the reactor cover slab. When the traveling crane hoisted the vessel or cap up, it was automatically inclosed in the cover, and when they were entirely lifted out of the reactor, the rubber ring tightened automatically, inclosing the vessel and cap in the protective cover. This equipment was easy to operate and prevented the scattering of radioactive dust; the results were excellent, there was no environmental pollution, and design requirements were met.



Figure 9. The protective cover for the vessel and aluminum cap (the transparent section is made of transparent plastic sheet to allow observation of the vessel surface).

(by Zeng Jiannong [2582 1696 6593]
and Tan Yixian [6151 1355 0341])

2.7 Turning the New Inner Vessel

The new inner vessel is a cylindrical container made of LT21 aluminum alloy 5.4 m long, with upper and lower diameters of 1.6 and 1.4 m respectively. The bottom of the cylindrical body has five water intake and outlet pipes 2.85 to 2.95 meters in length. It is brought into position by horizontal movement, but before it is installed it must be turned to a vertical position for insertion.

When the reactor was built, the inner vessel was rotated by the combined use of the main hook of the traveling crane and a temporarily installed hoist. When turning the vessel, the cylindrical sections and extensible joint were protected by clamps, struts and reinforcing bars.

We conducted a dynamic analysis and rigidity and strength calculations and used a new method following a dry run. The main and auxiliary hooks of the reactor room traveling crane were used to suspend the central suspension ring on the upper end and the cable on the lower end respectively, and the vessel was turned smoothly after being hoisted horizontally to a height of 3.5 m.

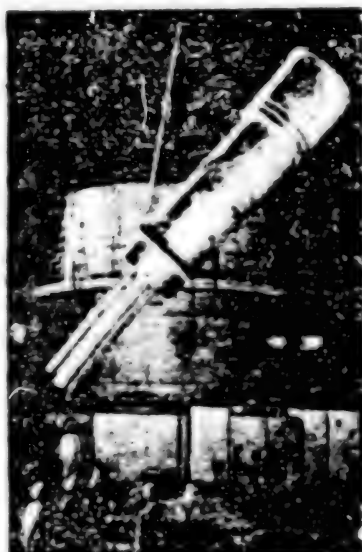


Figure 10. Turning the new inner vessel.

(by Song Lixin [1345 4539 2450] and
Shen Hongyang [3088 1347 2254])

2.8 The Contact Sensor

The five inlet and outlet tubes at the bottom of the inner vessel are rather long, are made of soft, not very rigid material, and are installed with small clearances.

When the vessel is installed in its place by remote control, the interior cannot be observed directly, and accordingly we installed two contact sensors on two symmetrically located water outlet pipe ends.

The contact sensor (see figure) is of the expansion plug type, in which a nut squeezes a rubber pad and causes it to expand inside the piping. The rod has an insulator around it, and a copper piece at the tip. If the contact head encounters

an obstacle, the electrical circuit emits an obstruction signal which stops operation, and the workmen can adjust the position of the vessel. In practice the device has proven to be simple in design, has given sensitive and reliable readings and has been easy to install and remove, and thus has served to protect the equipment.

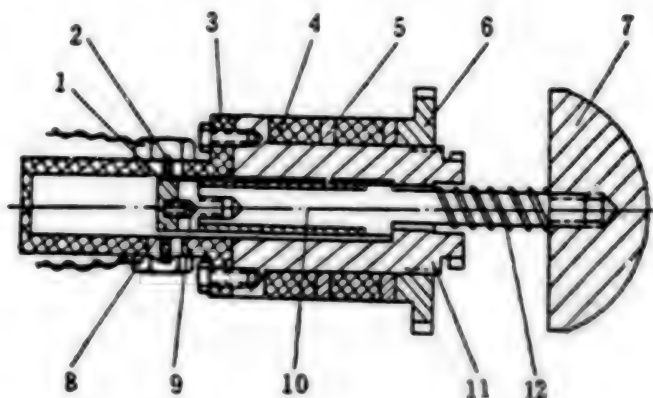


Figure 11. The contact sensor.

Key:

1. Copper contact
2. Spring
3. Bakelite cover
4. Rubber pad
5. Spacer
6. Nut
7. Semicircular head
8. Copper piece
9. Bakelite
10. Contact rod
11. Core
12. Spring

(by Zeng Jiannong)

Radiation Protection

1. Radiation Monitoring and Evaluation

A. Individual Dose Monitoring

In 1979 our institute used the following methods to monitor individual external radiation doses: beta-gamma film dosimeters, fluorescent glass dosimeters, and ring-type LiF thermoluminescent dosimeters, i.e. polyethylene film containing lithium fluoride. External doses of beta particles, gamma rays and neutrons were monitored. The beta-gamma film dosimeters had a detection period of a month, the fluorescent glass dosimeters 3 months, and the ring-type dosimeters a week. A

measurement can be made any time an extraordinary circumstance arises. Individual internal dose monitoring included: (1) analyzing the quantities of various radioactive nuclides in urine samples from the workers; and (2) using whole-body counters to determine the accumulated dose of gamma-emitting nuclides.

(1) Individual External Dose

In 1979, individual external dose monitoring was carried out for 713 persons. The collective dose received was equivalent to 581.90 man-rem (5.819 man-Sv), an average equivalent annual dose of 0.80 rem (8.0 mSv). The data on whole-body external radiation doses received by workers in 1979 are given in Table 3. The 15 persons who had dose levels exceeding the maximum permissible annual figure were all isotope production workers.

Table 3. Whole-Body External Radiation Doses Received by Personnel in 1979

dose equivalent range rem (mSv)	number of persons monitored	% of total
≤0.5(5)	432	60.6
>0.5—≤1.5(>5—≤15)	191	26.8
>1.5—≤2.5(>15—≤25)	50	7.0
>2.5—≤5(>25—≤50)	25	3.5
>5.0(>50)	15	2.1

The annual whole-body accumulated dose received by one of these persons was 24.0 rem (240 mSv), which was 4.8 times the maximum permissible annual equivalent dose. The main reasons were: (a) neglect of necessary on-site protection and monitoring when cleaning hot cells; (b) poor protection during some processes. The distribution of external radiation doses received by workers in different types of jobs are shown in Table 4.

Table 4. Distribution of Radiation Doses Received by Workers in Different Jobs

工 作 性 质 a	人 数 b	≤0.5rem (≤5mSv)	>0.5—≤1.5rem (>5—≤15mSv)	>1.5—≤2.5rem (>15—≤25mSv)	>2.5—≤5rem (>25—≤50mSv)	>5rem (>50mSv)
c 反应堆	331	216	99	15		
d 同位素生产	162	50	38	34	25	15
e 放射化学	23	13	10			
f 核物理实验	49	39	10			
g 保健物理	22	21	1			
h 三废处理	38	38				
i 其他	88	55	33			

[Key on following page]

Key:

- | | |
|-----------------------|--------------------------------|
| a. Nature of work | f. Nuclear physics experiments |
| b. Number of persons | g. Health physics |
| c. Reactor | h. Waste treatment |
| d. Isotope production | i. Other |
| e. Radiochemistry | |

(2) Individual Internal Radiation Doses

The main radioactive nuclides for which the urine of workers was analyzed in 1979 were ^3H , ^{106}Ru , radioactive strontium and total beta. In addition, the ^{239}Pu content of some workers' urine was monitored on an ongoing basis. The results are shown in Table 5.

Table 5. Results of Urine Analysis of Workers in 1979

a 被监测核素	b 被监测 人次	c 尿中各核素放射性 测量的参考水平	d 小于 $\frac{1}{2}$ 参考水平的 人次	e 等于或大于 $\frac{1}{2}$ 参考水平, 小于参考水平的人次	f 大于参考水平的 人次
^3H	248	$2\mu\text{Ci/l}$ ($7.4 \times 10^4 \text{Bq/l}$)	285	21	22
^{106}Ru	12	$0.3\mu\text{Ci/24h-Urine}$ (11.1Bq/24h-Urine)	12		
g 放射性锶	21	$50\mu\text{Ci/24h-Urine}$ (1.85Bq/24h-Urine)	21		
h 总 β	52	$50\mu\text{Ci/24h-Urine}$ (1.85Bq/24h-Urine)	38	13	1
i 总计	333		276	34	23

Key:

- | | |
|--|--|
| a. Nuclide monitored | e. Number of persons with more than 1/2 but less than 1x reference level |
| b. Number of persons tested | f. Number of persons with more than reference level |
| c. Reference level of nuclide in urine | g. Radioactive strontium |
| d. Number of persons with less than 1/2 of reference level | h. Total beta |
| | i. Total |

At the end of 1978 a whole-body counter developed by our institute went into use in routine monitoring. It was used primarily for monitoring of persons taking part in the overhaul of the reactor and ordinary operations personnel, but in addition monitoring was conducted on isotope production personnel and health physics personnel. None of the results exceeded 1 percent of the maximum permissible internal accumulation. (see Table 6)

Table 6. Results of Determination of Accumulated ^{137}Cs and ^{60}Co in Bodies of Reactor Workers

type of reactor	no. persons monitored	^{137}Cs , $\mu\text{Ci} (\$7\text{Bq})$			^{60}Co , $\mu\text{Ci} (\$7\text{Bq})$					
		≤ 2	≤ 5	≤ 10	≤ 2	≤ 5	≤ 10	≤ 20	≤ 50	≤ 100
heavy water	100 ^a (增大修改后 期 堆 置)	9	28	63	41	43	13	3		
	78 ^b (增大修改中)	17	31	30	19	36	12	5	3	3
swimming pool	90	45	28	17	66	24				
total	268	71	87	110	126	103	25	8	3	3

Key:

- a. Before reactor overhaul and reconstruction
- b. During reactor overhaul and reconstruction

(by Dong Liucan [5576 2692 3605])

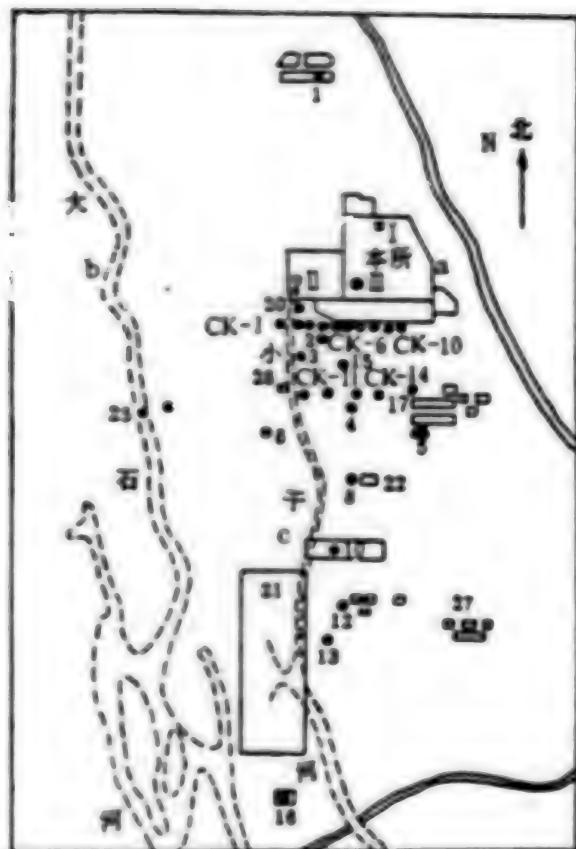
2. Environmental Radioactivity Monitoring

In 1979 our institute conducted environmental monitoring of gasborne effluents, liquid effluents and environmental media (air, water, plants). The radioactive nuclides which were analyzed and surveyed were: total alpha, total beta, ^{125}I , ^{131}I , ^3H , ^{90}Sr , ^{106}Ru and ^{137}Cs , in addition to gamma irradiation rates. The maximum radi of monitoring activity was 20 km. The locations of the air, water and plant monitoring stations are shown in Figure 12.

[Figure 12 and Key on following page]

Figure 12. Locations of Environmental Monitoring Stations

Key:



- I. Monitoring station #1
- II. Solid and liquid waste storage facility
- III. Heavy water reactor cooling tower
- 1. Shawo Village
- 2. Outside south wall
- 3. Northeast of weather station
- 4. West of Beifang Village
- 5. Beifang Village
- 6. Southwest of weather station
- 8. Southwest of sewage area
- 10. Firefighting equipment plant
- 12. West of Jiaozhuang
- 13. North of wooded area
- 15. Pond in Beifang Village
- 16. Normal school
- 17. Beifang Village vegetable plot
- 20. Main industrial wastewater discharge point
- 21. Bridge plant
- 22. Domestic sewage area
- 25. Dashi River wastewater discharge point
- 26. Weather station
- 27. Jiaozhuang Village
- a. Institute
- b. Dashi River
- c. Xiaogan River
- d. Location and number of monitoring point
- e. Road
- f. Watercourse

A. Air Monitoring

Our institute's gasborne radioactive effluents are discharged into the air primarily by eight 30-60 m smokestacks and several low smokestacks. The concentrations and total quantities of radioactive nuclides discharged into the atmosphere are shown in Table 7. One of the nuclides which are discharged in the largest quantities is ^{131}I . Measures are currently being taken to decrease discharges of ^{131}I and ^{125}I .

[Table 7 and Key on following page]

	total α	total β	^{131}I
concentration range, Ci/l (Bq/m ³)	$1.1 \times 10^{-11} - 2.8 \times 10^{-11}$ ($4.1 \times 10^{-1} - 1.0$)	$1.7 \times 10^{-11} - 1.2 \times 10^{-10}$ ($6.3 \times 10^{-2} - 44$)	$2.9 \times 10^{-12} - 4.9 \times 10^{-11}$ ($85 - 1.6 \times 10^4$)
annual dose C _i (Bq)	1.4×10^{-3} (5.2×10^7)	2.9×10^{-3} (8.5×10^7)	9.8 (2.6×10^{11})

	^{131}I	^{132}I	^{41}Ar etc.
concentration range Ci/l (Bq/m ³)	$(1.1 - 4.0) \times 10^{-11}$ ($41 - 1.5 \times 10^3$)		$(1.0 - 8.4) \times 10^{-9}$ ($3.7 \times 10^2 - 3.1 \times 10^4$)
annual dose C _i (Bq)	9.34 (1.3×10^{10})	113 (4.2×10^{12})	1.4×10^4 (5.2×10^{13})

Table 7. Radioactive Nuclides Discharged into the Atmosphere Through Smokestacks

Key:

- a. Concentration range
- b. Total amount discharged annually

B. Water Monitoring

Most of our institute's radioactive wastewater is discharged into the environment through one of two routes. The first is that weakly radioactive wastewater is discharged into the Dashi River during the rainy season after treatment. The other is that that radioactive waste with concentrations lower than the disposal limit are discharged directly into the Xiaogan River south of the institute. The main radioactive nuclide is ^3H (see Table 8).

Table 8. Quantity of Radioactivity Discharged into the Environment in Water

discharge location	Dashi River		Xiaogan River
discharge, tons	1.1×10^3		5×10^1
nuclide	total β	%	total β
conc. range Ci/l (Bq/m ³)	$(0.24 - 1.9) \times 10^{-11}$ ($(89 - 7.0) \times 10^2$)	$(0.3 - 5.5) \times 10^{-9}$ ($(0.11 - 2.0) \times 10^3$)	$4.3 \times 10^{-11} - 1.5 \times 10^{-10}$ ($(0.16 - 5.6) \times 10^3$)
total, C _i (Bq)	4.3×10^{-4} (1.6×10^9)	4.5 (1.7×10^{11})	2.8×10^{-1} (1.0×10^9)

When discharges were made into the Dashi River, the quantity of ^3H in the river water was monitored at a point not far from the discharge point. It was found that the concentration limits given by the state standards for surface water resources were not exceeded (see Table 9).

Table 9. Concentration of ^3H in Dashi River During Discharge of Radioactive Wastewater ($\times 10^{-9}$ Ci/liter (Bq/m^3))

distance to discharge site, m	60	100	400	1500
concentration range	2-4.4 [(7.4-16) $\times 10^4$]	2-6.6 [(7.4-24) $\times 10^4$]	2-4.7 [(7.4-17) $\times 10^4$]	2-2.9 [(7.4-11) $\times 10^4$]
avg. concentration	2.5 (8.3 $\times 10^4$)	3.2 (1.2 $\times 10^5$)	3.1 (1.1 $\times 10^5$)	2.2 (8.1 $\times 10^4$)

The results of monitoring of subsurface water during our institute for radioactive nuclides are given in Tables 10-12. The monitoring results show that the scope of subsurface water pollution downstream from our institute currently is still essentially constant south of the institute, north of the firefighting equipment plant, east of the weather station and west of Beifang Village. Other than that found in well CK-6, the concentrations are not in excess of state standards for concentrations in exposed water sources. Total beta radiation in the six monitoring wells 101-1 through 101-6 was lower than in 1978.

Table 10. Concentration of ^{90}Sr in Subsurface Water

location	conc. $\times 10^{-11}$ Ci/l range (Bq/m^3)
Shawo Village	8.7 (26)
outside south wall	22.0 (8.1 $\times 10^3$)
W of Beifang Village	5.4 (2 $\times 10^3$)
SW of sewage area	2.1 (78)
Beifang Vil. vegetable plot	2.1 (7.8)
CK-5	7.2 (2.7 $\times 10^3$)
CK-6	131.5 (4.9 $\times 10^3$)
CK-10	3.5 (1.3 $\times 10^3$)

Table 11. Concentration of ^{137}Cs in Subsurface Water

Location	concentration [$\times 10^{-3} \text{ Bq/m}^3$]
Shawo Village	75 [2.8 $\times 10^3$]
outside south wall	153 [5.6 $\times 10^3$]

Table 12. Concentration of ^3H in Subsurface Water

Location	conc. $\times 10^{-3} \text{ Ci/l}$ [Bq/m^3]	Location	conc. $\times 10^{-3} \text{ Ci/l}$ [Bq/m^3]
Shawo Village	2.8 [1.0 $\times 10^3$]	wastewater tank 101-1 monitoring well	5.3 [2.0 $\times 10^3$]
outside south wall	2.2 [1.2 $\times 10^3$]	101-2 "	45 [1.7 $\times 10^3$]
Beifang Village	4.6 [1.7 $\times 10^3$]	101-3 "	1.2 $\times 10^3$ [4.3 $\times 10^3$]
Beifang Village vegetable plot	5.4 [2.0 $\times 10^3$]	101-4 "	8.2 [3.0 $\times 10^3$]
CK-5 well	2.3 [0.9 $\times 10^3$]	101-5 "	4.9 [1.8 $\times 10^3$]
CK-6 well	3.2 [1.2 $\times 10^3$]	101-6 "	4.2 [1.6 $\times 10^3$]
CK-7 well	3.7 [1.4 $\times 10^3$]	E of water tower	17 [6.3 $\times 10^3$]
CK-10 well	4.4 [1.6 $\times 10^3$]	total discharge	5.2 [1.9 $\times 10^3$]

C. Vegetation Monitoring

There are three sampling points for vegetation monitoring: Shawo Village, Beifang Village and Lugou Bridge (control). Samples include vegetables, grain and oil plants. Surveys are made of total beta, beta other than potassium, ^{90}Sr , ^{137}Cs , ^{131}I , ^{125}I , K and Ca. Comparisons with the control point and with historical data do not show any significant pollution of vegetation in the vicinity of our institute with ^{90}Sr or ^{137}Cs . But the concentrations of ^{131}I and ^{125}I are relatively high in some plant samples. The maximum values on plant leaves are $1.6 \times 10^{-8} \text{ Ci/kg}$ ($5.9 \times 10^2 \text{ Bq/kg}$) and $1.3 \times 10^{-8} \text{ Ci/kg}$ ($4.8 \times 10^2 \text{ Bq/kg}$) respectively.

D. Gamma Radiation Monitoring

In order to evaluate the external radiation dose to which our institute subjects the public, we used a gamma radiation meter and a $\text{CaSO}_4:\text{Dy}$ thermoluminescence dosimeter to monitor gamma dosage rates in the vicinity of the institute. The average annual gamma radiation level inside the institute was 120 mR, the minimum value was 62 mR and the maximum value was 401 mR. The annual gamma radiation rate at 31 stations located within 15 km of the institute was 63-113 mR and the average value was 85 mR.

(by Guo Mingqiang [6751 2494 1730])

3. Radiation Monitoring During Reconstruction of the Heavy Water Research Reactor (by the Reactor Reconstruction Protection Group)

Our institute's heavy water reactor was shut down on 11 November 1978 for reconstruction, and cleaning began on 16 January 1979 (removal of all uranium slugs and control rods). More than ten high-radioactivity operations including dismantling and burial of the old vessel and installation of the new vessel, decontamination and overhaul of the heavy water circuits, disassembly, decontamination and overhaul of the three heavy water pumps, replacement of the two heat exchangers, and removal of sludge from the drain pond had been carried out by December 1979. The gamma radioactivity and energy spectrum of the old inner vessel of the reactor were determined on 5 June 1979 when it was hoisted out. The gamma dose at the upper opening of the vessel was 2.38 R/hr, the dose at the side 1.85 m from the central axis was 10.8 R/hr, and the dose 5 m from the axis was 1.14 R/hr. Conversion gives a total radioactive intensity of 30.9 Ci for the inner vessel, including a value of 21 Ci for ^{60}Co and 6.9 Ci for ^{65}Zn .

To decrease the internal and external doses received by the workers, we took the following main measures:

- (1) drawing up a specific plan for protection against radiation in highly radioactive operations;
- (2) estimating the dose which the workers were likely to receive during each main operation and the main problems which should be given attention;
- (3) maximum possible use of remote control and automatic operation, such as automatic electric sawing of the channels and the like;
- (4) chemical decontamination and partial shielding of the heavy water system;
- (5) strict separation into zones and timely monitoring and decontamination of the work area;
- (6) strict control of worker time spent in high-radioactivity areas;
- (7) intensified work area ventilation;

(8) technical training and testing of operators, including a full-scale dry run with the inner vessel, the protective cover and the like;

(9) in order to protect highly trained personnel from being the only ones to carry out operations involving high levels of radioactivity, we organized a group of non-radioactive area workers or workers who ordinarily were not involved with high-radioactivity operations to do auxiliary work such as decontamination, sludge removal, transport of wastes and the like.

A. Individual Dose Monitoring

Some 199 workers took part in the overhaul and reconstruction of the reactor, and the total annual collective equivalent gamma ray dose was 108.0 man-rem, giving an average annual equivalent dose of 0.54 rem. Two workers received rather large equivalent gamma ray doses: 2.2 rem in one case and 2.17 in the other.

Internal irradiation monitoring methods included determination of tritium and total beta in the urine and whole-body counts. The tritium and total beta determination results are shown in Table 13 and the results of total body counts for internal gamma emitters are shown in Table 14.

Table 13. Radioactive Nuclides in the Urine of Workers

nuclide	number of persons tested	testing results		reference level
		concentration range	no. of persons	
tritium	157	<0.1 $\frac{\mu\text{Ci}}{\text{l}}$	37	2 $\frac{\mu\text{Ci}}{\text{l}}$
		0.1-1 "	97	
		1-2 "	15	
		2-10 "	7	
		10-20 "	1	
total β	45	<2 $\frac{\text{pCi}}{24\text{h-urine}}$	17	50 $\frac{\text{pCi}}{24\text{h-urine}}$
		2-20 "	26	
		20-50 "	2	

Table 14. Whole-Body Gamma Emitter Results for Workers

nuclide	number of persons tested	testing results		max. permissible accumulation in μCi body
		concentration range, mCi	no. of persons	
^{60}Co	78	<0.01	69	10
		0.01-0.1	9	
^{137}Cs	78	<0.01	78	30

It can be seen from Tables 13 and 14 that owing to the measures described above, most workers showed urine radioactive nuclide levels much lower than the reference levels, and only a very small number of workers had urine tritium levels 5-10 times as high as the reference levels. The accumulated quantities of gamma emitters (primarily ^{60}Co and ^{137}Cs) were all less than 1 percent of the maximum permissible values.

B. Monitoring in the Work Area

The highest tritium concentrations in the air were found in the heavy water pump room, followed by the reactor room; the annual average values were 2.5×10^{-9} Ci/liter and 1.5×10^{-10} Ci/liter respectively. The tritium concentrations in the air of the basement hall and first, second and third story halls were relatively low: all were 5×10^{-12} Ci/liter.

The concentration of beta aerosols in the air of the work area was consistently between 10^{-14} and 10^{-13} Ci/liter, but reached 10^{-12} - 10^{-11} Ci/liter for brief periods during certain operations (such as disassembly of the heavy water pumps, decontamination of the water circuits and the like). The main radioactive nuclide was ^{60}Co .

C. Radioactive Wastes

The total quantity of tritium emitted through the smokestack for the entire year was 113 Ci, and the total quantity of beta aerosol discharged was 7.7 mCi.

The amount of highly radioactive wastewater discharged was 38 tons, including a total beta radioactivity of 144.8 Ci, and 231.2 Ci from tritium. This radioactivity resulted primarily from decontamination of the heavy water circuit. The total quantity of weakly radioactive wastewater discharged was 97.2 tons, containing 0.75 Ci of total beta and 1.8 Ci of tritium. There were 9 barrels (0.1 m^3 each) of strongly radioactive sludge; the gamma radiation rate on the outer surface of the barrels was 0.9 to 1.8 R/hr, and the relative radioactivities of the sludge were: 1.7 mCi/kg of ^{60}Co , 4.3×10^{-2} mCi/kg of ^{137}Cs , and 3.1×10^{-2} mCi/kg of ^{144}Ce .

The total quantity of strongly radioactive solid waste produced over the year was 10 cubic meters, and the total quantity of weakly radioactive solid waste was 58 m^3 ; this waste was stored in a waste storage facility.

D. Problems

1. Because there were no special protective facilities, the heavy water pumps were placed in an area of the reactor room for overhaul (a cement wall 1.8 m high was placed around the pumps), resulting in serious contamination of the overhaul area and the surrounding wall. In the future such operations will be carried out in a special overhaul area.
2. Contamination of working clothes and footwear usually exceeded permissible levels, and plans have been made to provide replacements after complete decontamination of the work area.

(by Pan Ziqiang [3382 5261 1730],
Jiang Xiwen [1203 1585 2429] and
Chun Yuqing [2504 3768 0615])

4. Surveys of ^{131}I and ^{125}I Contamination of Plants in the Vicinity of the Institute of Atomic Energy Research and Determination of Relative Parameters

In 1979 a survey was made of ^{131}I and ^{125}I contamination of plants in the vicinity of the institute. The methods were as follows: the day after production of ^{131}I and ^{125}I , at 16 locations within 20 km of the smokestack, following low-level background gamma spectroscopy and radiochemical concentration, low-level background beta emission monitoring equipment and X-ray spectrometers were used to determine the intensity of contamination of plants by ^{131}I and ^{125}I respectively. Figures 13 and 14 show ^{131}I contamination in July and August.

The main data on ^{131}I and ^{125}I contamination are given in Tables 15 and 16. When ^{131}I was produced, the ^{131}I contamination of plants was the highest, gradually dropping off, and manifesting cyclic changes in accordance with the production of ^{131}I . The ^{125}I level showed a month-by-month increase at short distances.

In the specific emission conditions of our institute, the apparent half life of ^{131}I in plants was 7.4 days, and the washing factor (after washing/before washing) was 0.60 to 0.80. Agricultural crops which had a long growing period in the contaminated areas had ^{131}I and ^{125}I levels in their fruits equivalent to about 10 percent of the levels on the leaves.

Because of the nonuniform discharge of ^{131}I during the production process, a determination of the correlation between the process flow and ^{131}I discharges was made. It was found that when acidic distillation residues were directly discharged into the high-radioactivity piping after production, ^{131}I concentrations were two orders of magnitude higher than in discharge during other procedures, and when the iodine isotope production shop temporarily stored its distillation residues in a relatively well sealed plastic barrel, the total quantity of ^{131}I discharged into the environment showed a rather marked decrease.

Table 15. Main Aspects of ^{131}I Contamination During July-September

month	main contamination direction	distance to point of max. contamination,	max. contamination, 10^{-9}Ci/kg	max. distance at which contamination is $1 \times 10^{-12}\text{Ci/kg}$
7	SSW	1600 meters	4.57	15
8	NNE	600	16.20	25
9	NNE	400	8.11	20

Table 16. Main Aspects of ^{125}I Contamination

month	main contamination direction	distance to point of max. contamination	max. contamination, 10^{-9}Ci/kg	max. distance at which contamination is $1 \times 10^{-12}\text{Ci/kg}$
7	NNE	200 meters	2.06	
8	NNE	200	4.66	20
9	NNE	400	12.8	20
10	NNE	600	10.2	

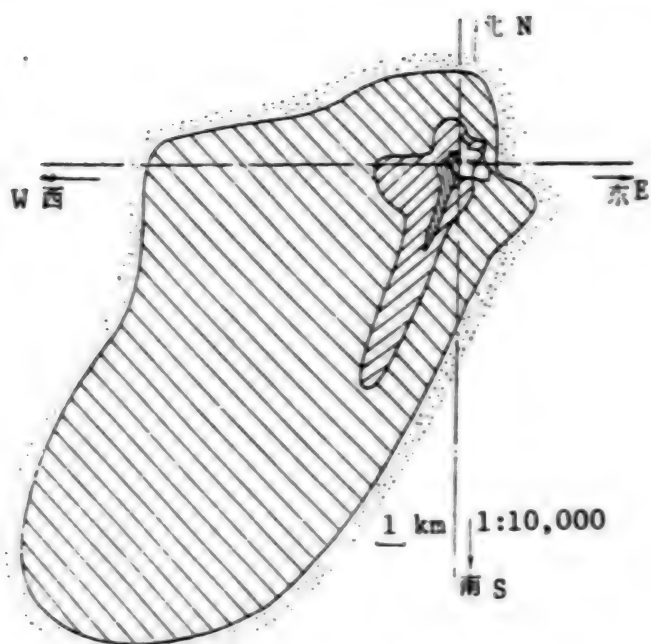


Figure 13. ^{131}I Contamination in July (see legend of Figure 14b).

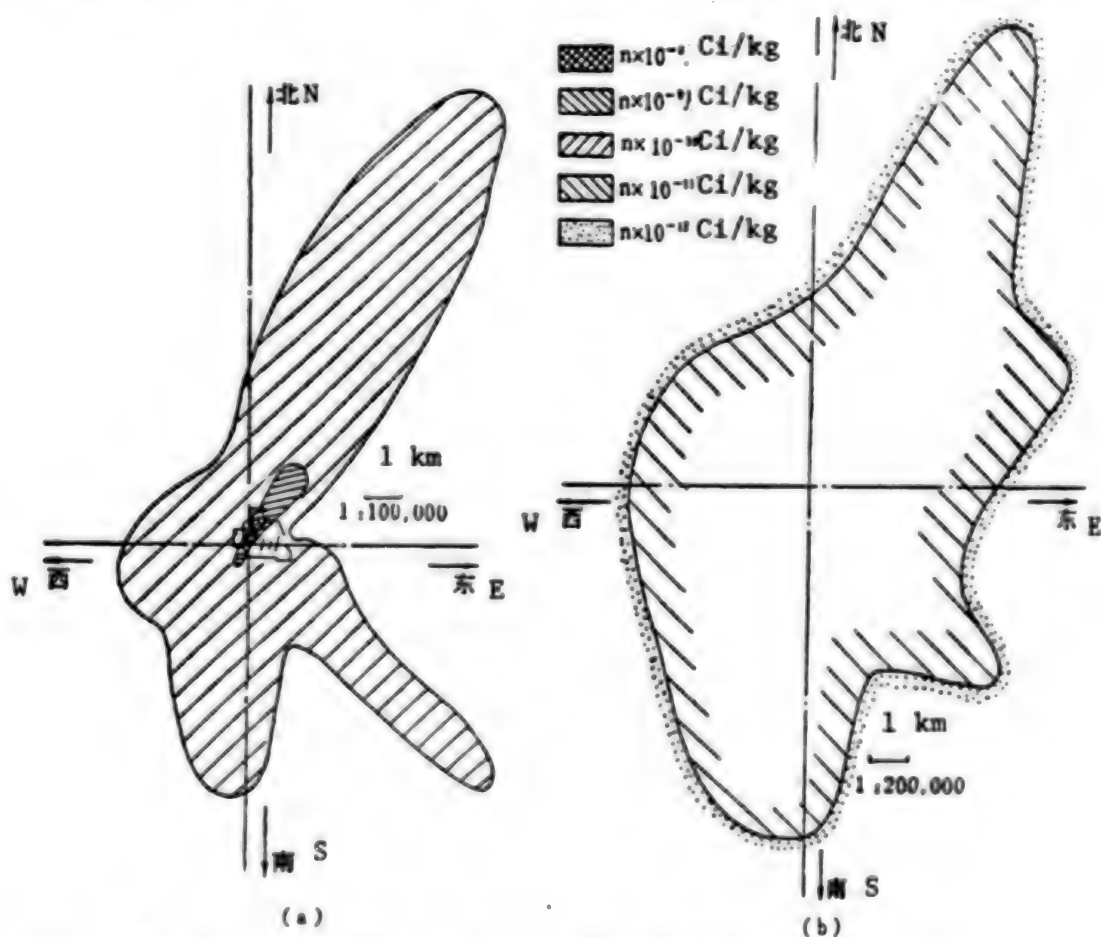


Figure 14. ^{131}I Contamination in August (for legend, see part b).

(by Xie Yunmian [6200 6663 2758])

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CSO: 8111/1423

LIFE SCIENCES

SELENIUM DEFICIENCY SAID CAUSE OF KESHAN DISEASE

Shanghai WENHUI BAO in Chinese 13 Jul 81 p 1

[Article: "Our Nation's Medical Workers Made a Major Discovery After Many Years of Research; Deficiency of Selenium Is a Cause of Keshan Disease; The Important Function of Selenium in Human Health Is Demonstrated Internationally for the First Time"]

[Text] Our nation's medical workers discovered that selenium deficiency is a cause of Keshan disease which is very harmful. This new achievement has opened up a road for the effective prevention and control of Keshan disease and it has also proven for the first time internationally that selenium is a necessary trace element in the human body, therefore it has received high evaluation and attention by experts of other nations.

Keshan disease is a regional myocardial disease widely distributed in farm villages in 15 provinces and regions of Heilongjiang, Jilin, Shaanxi and Yunnan. Patients are mostly children and women, the death rate is very high. Because the cause of the disease is not clear, there has not been any specially effective method of prevention and treatment.

After Liberation, the party and the government paid a lot of attention to prevention, treatment and research of Keshan disease. Several national academic meetings were held to discuss the subject and specialized agencies were established in each region where the disease was found to carry out comprehensive measures to actively prevent and control it. Comrade Zhou Enlai, when he was alive, sent Beijing's medical specialists of leading medical teams to the regions severely affected by the disease many times. He also personally instructed that "we should clearly understand the cause of Keshan disease."

For several decades, the medical circle studied Keshan disease from many aspects, and some people proposed the theory of poisoning, infection and malnutrition but these theories were never fully proven. In the 1960's, Xian Medical Academy and the Chinese Academy of Medical Sciences obtained preliminary results using sodium selenite in tests of a few patients to prevent Keshan disease. This caused them to notice the relationship between selenium and Keshan disease. After 1974, the Keshan disease research and treatment squad of the Chinese Academy of Medical Sciences and the Xian Medical Academy cooperated with over ten provincial units throughout the nation and conducted large scale research in the preventive effects of sodium selenite for 7 consecutive years. Some 12,000 tested patients were strictly observed and compared and it was proven that using sodium selenite could

reduce the percentage of occurrence of Keshan disease by 85 percent and the death rate could be reduced by over 88 percent. At the same time, they made 10,000 selenium content measurements in samples of food grains, human blood, hair and urine in the regions of the disease and proved that the regions of the disease were all regions of low selenium. The residents in the regions of the disease were all in a state of selenium deficiency. After taking sodium selenite, the selenium content in the bodies of those in the regions where the disease was found was increased to that of those in regions without the disease, and the related metabolic functions of the human body improved.

According to preventive research in large areas and massive scientific data of the inner environment, medical workers proposed that selenium deficiency is a cause of the occurrence of Keshan disease and selenium is a trace element needed by the human body. This was the first international revelation of the important function of selenium in the health of the human body. It overturned the view that selenium is a poisonous substance which cannot be used in the human body and turned selenium research from animals to people. At the second international conference on the function of selenium in medicine and biology held last year, this observation of Chinese medical workers was confirmed by specialists of all nations.

Trace amounts of the element selenium has brought good news to the people of the regions of the disease. Up to the present, over 1.5 million people in the 15 Keshan disease regions throughout the nation have used the method of supplements of selenium to prevent Keshan disease and visible results have been obtained. The number of patients suffering from Keshan disease in Heilongjiang, the key region of Keshan disease, has dropped year after year. In 1979, there were 386 patients, in 1980, the number dropped again to 176, a great reduction from the past. At the locality where Keshan disease was discovered--Keshan county--there were only two patients last year.

9296

CSO: 4008/424

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TITLE: "Simulation and Efficiency of Large Tray (II)--Two Dimensional Fixed Number Mixing Pool Model"

SOURCE: Beijing HUAGONG XUEBAO [JOURNAL OF CHEMICAL INDUSTRY AND ENGINEERING]
in Chinese No 2, Jun 81 pp 97-110

TEXT OF ENGLISH ABSTRACT: A new mathematical model of the mixing pool type is proposed to simulate the fluid flow and mass transfer behavior in a large tray. In the proposed model, the whole tray deck is divided into a number of square (or rectangular) compartments or mixing pools, each of which is assigned to have adjustable flow and backmixing in both the z (along the main flow path) and w (perpendicular to the main flow path) directions. The chief features of the present model are: (1) It is a two-dimensional model instead of the usual one-dimensional so that more complicated actual flowing conditions obtained from the hydrodynamic study in the large tray can be closely simulated by adjusting the flow among the mixing pools in both the z and w directions. (2) Since backmixing is taken into account, the number of mixing pools in a tray can be fixed instead of varied as is the case in the conventional mixing pool model; thus, the application of matrix computation is possible. (3) The present model can be reduced to other tray models depending on the number of mixing pools to be chosen in each direction.

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The application of the present model to prediction of the liquid phase concentration profiles and Murphree efficiencies in a tray with complicated flow pattern and velocity distribution, as observed in our experimental study, is demonstrated. The effects of the liquid flow rate, non-uniform velocity field, directional splashing and subsidiary flow are also investigated and discussed.

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TITLE: "Parameter Estimation by Fourier Analysis--Determination of Gas-particle Heat Transfer Coefficient in Packed Bed"

SOURCE: Beijing HUAGONG XUEBAO [JOURNAL OF CHEMICAL INDUSTRY AND ENGINEERING] in Chinese No 2, Jun 81 pp 111-123

TEXT OF ENGLISH ABSTRACT: A stimulus-response technique is used to determine gas-particle heat transfer coefficient in a packed bed. The input signal is a one-shot temperature impulse of arbitrary shape and at a distance downstream from the input point the temperature response is measured.

The mathematical model adopted for the packed bed is a one-dimensional heterogeneous dispersion-concentric model. The Laplace transform method is used in the solution of the partial differential equations of the model. As the resulting transfer function is too complicated, a Fourier analysis method is applied. The input and response signals are both expanded in Fourier series form. The Fourier coefficients of the response signal can be predicted directly from those of the

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input signal and the transfer function and thus the calculated response signal function is obtained, which can then be fitted with the measured one to carry out the parameter estimation. In the procedure of curve fitting the mean square deviation between calculated and measured response functions in the whole time domain is minimized.

It is found that the results of this work can be put into an expression assuming the same form of a known correlation of mass transfer

$$Nu = 2 + 1.1 Pr^{1/3} Re^{0.6}$$

in which the Nusselt number Nu contains the gas-particle heat transfer coefficient determined. The result also shows that in the laminar flow regime the Nusselt number of gas-particle heat transfer does not decrease appreciably with the decrease in the Reynolds number.

The experimental equipment is also described in the paper.

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TITLE: "The Kinetic Performance of Ammonia Synthesis Catalyst Al10 under the Effect of Trace Water Vapor"

SOURCE: Beijing HUAGONG XUEBAO [JOURNAL OF CHEMICAL INDUSTRY AND ENGINEERING] in Chinese No 2, Jun 81 pp 125-134

TEXT OF ENGLISH ABSTRACT: This paper discusses the investigation on the effect of reactive activity of quadruply promoted ammonia synthesis catalyst Al10 by using a synthesis gas containing $< 5 \sim 30$ ppm water vapor under high pressure. The experimental data were treated with the modified T-P equation. We have found that the poisoning factor $POIS = k/k_{T0}$ is approximately in inverse proportion to $\sqrt{V_{H_2O}}$ and proportional to the sixth power of absolute temperature, and is minimally related to pressure.

The catalysts appeared to be inflicted by poison when the water vapor reached $P_{H_2O}/P_{H_2} \approx 10 \times 10^{-6}$. The intrinsic apparent energy of activation rose from 38,000 kcal/kg-mol to 40,000 kcal/kg-mol or higher as the amounts of water vapor poisons increased. In comparison with the catalysts' original intrinsic activities,

[Continuation of HUAGONG XUEBAO No 2, Jun 81 pp 125-134]

appreciable change of kinetic performance under poisoning conditions, especially in the lower temperature region, has been acquired.

After 15 days of repeated poisoning experiments it is discovered that most of the catalytic activity has been recovered, but a certain degree of its activity was permanently destroyed by the poison.

Calculation of the empirical correlations of the poisoning factor of trace water vapor has been procured.

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TITLE: "A Study on Lead Dioxide Electrode--Composite $\text{PbO}_2/\text{Sb-SnO}_2/\text{Ti}$ Anode"

SOURCE: Beijing HUAGONG XUEBAO [JOURNAL OF CHEMICAL INDUSTRY AND ENGINEERING]
in Chinese No 2, Jun 81 pp 135-140

TEXT OF ENGLISH ABSTRACT: A new composite PbO_2/Ti anode with an interlayer of Sb-doped SnO_2 was prepared. The resistivity and components of the interlayer were determined by the four-probe method and X-ray diffraction respectively. Comparisons of the contact resistance and operating life of the PbO_2 electrodes with and without the interlayer showed that the composite $\text{PbO}_2/\text{Sb-SnO}_2/\text{Ti}$ electrode was good in performance and can be used for practical purposes.

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TITLE: "Study on the Radiation-induced Bulk Polymerization of Chlorotrifluoroethylene--The Effect of Radiation Conditions on Polymerization Progress and Zero-strength Temperature of Polymers"

SOURCE: Beijing HUAGONG XUEBAO [JOURNAL OF CHEMICAL INDUSTRY AND ENGINEERING]
in Chinese No 2, Jun 81 pp 141-150

TEXT OF ENGLISH ABSTRACT: The effect of radiation conditions on the polymerization progress and zero-strength temperature (ZST) in the radiation-induced bulk polymerization of chlorotrifluoroethylene is presented in order to bring to light the regularity by which high quality products may be prepared.

When changing the dose (D), dose rate (I) and radiation temperature (T), the kinetic progress remains smooth.

One of the principal factors for controlling the product quality, i.e., ZST, has been especially discussed and a relation between the factors affecting ZST is obtained. This relation provides the basis for the selection of conditions for preparing products with various properties:

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when $t \leq 20^\circ\text{C}$, $ZST = 1.75 \cdot 10^{-2} \cdot T^{0.9} \cdot I^{-0.39} \cdot D^{0.39}$;
when $t \geq 20^\circ\text{C}$, $ZST = 4 \cdot 10^8 \cdot T^{-3.3} \cdot I^{-0.36} \cdot D^{0.39}$.

The test results testify that the products from the bench-scale experiment have good thermal stability, excellent mechanical properties, reproducible quality and high purity. The technological process is simple.

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TITLE: "An Investigation of Fluid Dynamics and Characteristics of Mass Transfer in Corrugated Packing Made of Two Layers of Stainless Steel Gauze"

SOURCE: Beijing HUAGONG XUEBAO [JOURNAL OF CHEMICAL INDUSTRY AND ENGINEERING]
in Chinese No 2, Jun 81 pp 151-156

TEXT OF ENGLISH ABSTRACT: This packing is a new high efficiency and regular packing. The use of two layers of stainless steel gauze gives good wettability and uniform liquid distribution over the entire packing surface so that the separation efficiency is increased sensibly even with liquids of high surface tension, such as water, and under low liquid loads.

Vacuum rectification tests of D_2O/H_2O system have been performed with a column of 10 cm inside diameter, packing height of 200 cm, and column top pressure about 125 torr. By using the measured data, satisfactory correlations for pressure drop and mass transfer of this packing were obtained, as stated in the article.

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TITLE: "The Determination and Correlation of the Hydraulic Performance of Several Kinds of D_g50 Random Tower Packings"

SOURCE: Beijing HUAGONG XUEBAO [JOURNAL OF CHEMICAL INDUSTRY AND ENGINEERING] in Chinese No 2, Jun 81 pp 157-168

TEXT OF ENGLISH ABSTRACT: In this article, the pressure drop data at different gas velocities and flooding point data have been measured with the air-water system at different irrigating rates for 11 random tower packings of D_g 50 mm. We found some disadvantages in J.S. Eckert's method and think that it is not suitable for use as the foundation for further modification.

Based on the research done by our predecessors, we have, in this article, suggested two new equations, one for calculating the flooding velocity,

$$W_f = 0.003642 \left(\frac{\gamma_L^{0.7}}{\gamma_G^{0.1} \mu_L^{0.1}} \right) (\sqrt{\alpha \cdot d_p^{0.25}} - 0.1548 L^{0.07})^2$$

and the other for calculating the pressure drop

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$$\Delta P = \frac{mY}{1 - nY}$$

where

$$Y = \frac{W(\gamma_G^{0.25} \mu_L^{0.25} \gamma_L^{0.7})}{(\sqrt{\alpha \cdot d_p^{0.25}} - 0.1548 L^{0.07})^2}$$

which has successfully correlated our data and obtained the characteristic value--form coefficient α and pressure drop constant m , n for 11 kinds of packing.

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TITLE: "Calculation of Vapor-Liquid Equilibria for Systems of n- and iso-butanol Purification Process by UNIFAC--Supplement of Group Interaction Parameters, α CCOH, CHO and α CHO, CCOH"

SOURCE: Beijing HUAGONG XUEBAO [JOURNAL OF CHEMICAL INDUSTRY AND ENGINEERING] in Chinese No 2, Jun 81 pp 169-177

TEXT OF ENGLISH ABSTRACT: In this work, a pair of group interaction parameters, α CCOH, CHO and α CHO, CCOH, used in the UNIFAC group contribution method, has been supplemented with experimental vapor-liquid equilibrium data of iso-butanol iso-butanaldehyde system available from the literature. The UNIFAC method has been used in phase equilibrium calculations for systems of n- and iso-butanol purification processes with accuracy approaching or attaining that of results calculated by NRTL and other correlations. In view of the fact that the UNIFAC method is based on the assumption of the additive property of group properties, it is necessary to check the calculating results with a few experimental data and to make appropriate choices of the available group parameters.

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TITLE: "Mathematical Proof of the Second Law of Similitude Theory"

SOURCE: Beijing HUAGONG XUEBAO [JOURNAL OF CHEMICAL INDUSTRY AND ENGINEERING] in Chinese No 2, Jun 81 pp 179-186

TEXT OF ENGLISH ABSTRACT: The three laws of similitude theory are the essence and center of the whole theory. This paper presents the second law of similitude theory, or the π -theorem, a mathematical proof.

The method and steps adopted here for proof fit well to the π -theorem both in functional analysis and dimensional analysis.

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TITLE: "An Application of High-speed Magnifying Photography on the Model Test of an Industrial Burner"

SOURCE: Beijing HUAGONG XUEBAO [JOURNAL OF CHEMICAL INDUSTRY AND ENGINEERING]
in Chinese No 2, Jun 81 pp 187-191

TEXT OF ENGLISH ABSTRACT: High-speed magnifying photography is an economical non-intrusive measurement method. It can be used to measure the droplet size in flight. This paper describes the measurement theory, experimental devices and measurement results of this technique used for the determination of droplets atomized by an industrial burner.

For this test, the sauter mean diameters measured by the industrial burner are 58 microns at 400 mm section and 62 microns at 500 mm section respectively.

The test results are satisfactory, with relative error less than 8 percent. The minimum measurable droplet size is 12 μ .

9717
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TITLE: "Analysis of Thermal Engineering Problems by Exergy"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 1-7

TEXT OF ENGLISH ABSTRACT: In this paper the author attempts to solve thermal engineering problems by the exergetic method as follows:

1. First of all, four more definite and clearer definitions of exergetic efficiency are presented. Then, separate definitions of reasonable exergetic efficiency are also given for the different kinds of thermal engineering equipment for different uses.
2. Emphasis is placed on the analysis of exergy of the steady flow process with perfect gas as the working substance. From such an analysis it is shown that the exergy of a steady flow process of perfect gas can be divided into two different kinds of capabilities of work exclusive of the constant-zero exergy e_0 , which characterizes the difference in mass transported between the steady flow and the surrounding medium. Now the steady flow process in a fluid machine with perfect gas as the working substance can be described by stagnation enthalpy exergy e_i^* and stagnation pressure exergy e_p^* instead of stagnation enthalpy i^* and stagnation pressure p^* . The two different kinds of capability of work can be

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distinguished and eventually a further development of exergetic analysis can be brought about.

3. The objective function of the thermal engineering equipment is depicted by exergetic efficiency so as to examine whether more reasonable results can be reached with other than the traditional approach of analysis through this objective function--thermal efficiency. According to the author, this will depend on the coherence of variation of exergetic efficiency against the parameter analyzed with thermal efficiency. If the coherence does not appear, more reasonable results can be obtained. Otherwise they will never be obtained.

4. As for the exergetic analysis of a weak part where improvement should be made, through use of an example it is shown that the weak part can only be determined correctly by the following approaches:

- (1) By comparing the magnitudes of exergy losses for various parts of given equipment;
- (2) By comparing the magnitudes of exergy losses for the same part of different kinds of thermal engineering equipment;
- (3) By rigorously distinguishing two different kinds of exergy losses, i.e., stagnation enthalpy exergy losses and stagnation pressure exergy losses.

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TITLE: "Mathematical Model of the Evaporating System with Natural Circulation"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 8-13

TEXT OF ENGLISH ABSTRACT: A multivariable mathematical model of the evaporating system with natural circulation is derived. This model, which consists of several lumped-parameter sections, is based on the linked use of linear and quasilinear ordinary differential equations with algebraic equation sets, and is suitable for real-time digital simulation of the transient behavior of such a system over large operational ranges. Most of the results correlate well with field tests.

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TITLE: "Dual Heat Source Steam Cycle--A Power Plan of Combined Solar and Fuel-burning Heat"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 14-16

TEXT OF ENGLISH ABSTRACT: A new steam cycle for an electric station which utilizes combustion gas as a high temperature heat source and solar heat collected by the fixed tilt solar collector as a low temperature heat source is proposed. The main purpose of this paper is to promote the utilization of solar heat so as to save fossil fuel.

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TITLE: "Some Problems in the Aerodynamic Design of Energy Recovery Particulate Gas Turbines and Analysis of Test Results"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS] in Chinese Vol 2 No 1, Feb 81 pp 17-19

TEXT OF ENGLISH ABSTRACT: After a brief description of the phenomenon of particulate gas flow in turbine blade passage, the fundamental equations of two-phase flow are derived based on a two-velocity model. If the particle size and concentration are small, the simplified one-velocity model leads to an equation similar to that of pure gas flow except for the equivalent density. The aerodynamic design considerations of such turbines are then discussed, and test results with some analysis are given.

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TITLE: "Theoretical Investigations and Experimental Research for Higher Subsonic Two-dimensional Compressor Cascade"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS] in Chinese Vol 2 No 1, Feb 81 pp 20-27

TEXT OF ENGLISH ABSTRACT: The losses occurring in the air flow of a compressor cascade are mainly controlled by the developing and separating of the boundary-layer on the surfaces of the blade. Therefore, by means of adapting the theory of a compressible turbulent boundary layer, utilizing some characteristic parameters, such as momentum thickness, form factor, energy factor and other combination parameters, and then determining the flow model of simple power of velocity distribution in the wake behind the cascade, a simplified calculating equation for total pressure loss coefficient of subsonic and transonic cascades of the compressor is derived. The basic calculating equation derived would be used for predicting the total pressure losses of both design condition and off-design condition of the compressor cascade.

In this paper a new curvilinear method for correcting the gaseous compressible effect under higher subsonic and transonic intake conditions upstream of the cascade

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is presented. According to this basic equation, the total pressure losses for a given compressor cascade are calculated, and then tested on the plane wind tunnel under various conditions, with both results being in better agreement than previously.

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TITLE: "The Shock Wave Structure and Analysis of the Flow through Transonic Turbine Cascade"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS] in Chinese Vol 2 No 1, Feb 81 pp 28-34

TEXT OF ENGLISH ABSTRACT: Through a lot of Schlieren photos from the aerodynamic experiments of the transonic turbine cascade, the mechanisms of the generation and development of the shock waves in the channel and exit flow field of the cascade are studied. In these photos, there is a series of deflected shock waves from the free boundary of the jet. Through the analysis of this physical phenomenon, a satisfactory explanation of the aerodynamic performance which has a multipeak type of curve is obtained. In the third part of this article, three types of interaction between shock waves and the boundary layer are observed and discussed simply.

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TITLE: "Theoretical Analysis of the Stream Surface of Revolution with Supersonic Inlet Flow in a Transonic Axial Compressor"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS] in Chinese Vol 2 No 1, Feb 81 pp 35-42

TEXT OF ENGLISH ABSTRACT: Starting from jumps of absolute velocity and its tangential component due to changes of magnitude and direction of the relative velocity while passing through a shock and using the relations for a plane oblique shock, the expressions for $\Delta(V_{\theta r})$ loss and total pressure ratio of gas are derived and the fact that the gas is supercharged across the shock is explained theoretically. An aerothermodynamic analysis of the stream surface of revolutions with supersonic inlet flow is made by assuming the location and shape of the passage shock and applying the characteristic method in the inlet region. Some of the important features in a transonic compressor can be seen from the analysis. The moment of velocity from such calculations is close to that given in the calculation of inverse

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problems along a central S_2 stream surface. There are great differences in the Mach number distribution between the calculations of the central S_2 stream surface with the $V_{\theta r} - \Delta s/R$ variations and the stream-filament thickness, in which the shock relations are taken into account as input, and of the conventional average S_2 stream surface.

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TITLE: "The Effects of Trailing Vortex in Subsonic Rotor"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 43-45

TEXT OF ENGLISH ABSTRACT: This note presents a formula accounting for the effects of a trailing vortex in an annular duct rotor. The numerical example at $M_z = 0.5$, $M_t = 0.9$ and $pb \neq 1$ vividly indicates the streamline shifts caused by existing trailing vortices. Calculation also points out that the performances of an original rotor would be spoiled by cutting the blades.

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TITLE: "Primary Research on Ablation Experiment Technique of the Turbulent Flow over a Flat Plate Specimen"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 46-52

TEXT OF ENGLISH ABSTRACT: A new method utilizing a flat plate specimen placed at a small angle to a supersonic arc heated flow has been developed. This method can surmount the disadvantages of the usual pipe test method. Its observable recession rate is relatively uniform, and surface temperature and radiant heat flux can be easily performed.

This paper presents the experiment principles, the configuration of the facility, and the measurement and theoretical calculating method of the parameters. The study was accomplished with measured reservoir pressures ranging from 10.2 to 17.3 kg/cm² and total enthalpies from 520 to 2440 kcal/kg. Under five turbulent conditions the ablation test results of teflon models are given.

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TITLE: "Effect of Sinusoidal Heat Flux Distribution and Double-side Heating on Heat Transfer Coefficient in Annuli"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 53-59

TEXT OF ENGLISH ABSTRACT: In this paper the experimental investigation of turbulent heat transfer to air in annuli is described, the effect of sinusoidal heat flux distribution and double-side heating on heat transfer coefficients is analyzed, and corresponding empirical correlations are presented. In addition, the superposition principle is applied to annuli heat transfer calculations and the heat transfer coefficient correlation for axially varying heat flux is obtained. Calculation results show good agreement with our experiment.

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TITLE: "Numerical Calculation of Laminar Flow and Heat Transfer in an Entrance Region of a Circular Tube with Uniform Heat Flux"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 60-66

TEXT OF ENGLISH ABSTRACT: To date, in order to predict velocity and temperature profiles in an entrance region of a circular tube with uniform flux, the integral method is usually utilized and, in general, the assumptions of fully developed flow and $\mu = \text{constant}$ are made. In this paper the method of numerical calculation is used. The calculation is carried out for $\mu = \text{constant}$ and $\mu = f(T)$ respectively. The velocity and temperature distributions on various cross sections and along the axis are obtained, as is the length needed for fully developed flow. The agreement of predicted results with experimental data is quite good. It is found that the variation of μ with temperature has great influence on the results.

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TITLE: "Experimental Research on Combined Convective Heat Transfer Process of Turbulent Co-direction Flow Occurring in Vertical Annular Tube"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 67-69

TEXT OF ENGLISH ABSTRACT: According to the experiment results and analyses provided in this paper, the laminarization in the combined convective heat transfer process of the turbulent-natural co-direction flow is affirmed. The effects of Re and Gr (or Gr/Re^2) on the heat transfer process in such a combined convective condition are analyzed. The heat transfer correlations are given.

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TITLE: "Air Cooling in Turbine Rotors and Calculation of the Temperature Field of a Fir-tree Blade Root Assembly by the Finite Element Method"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 70-72

TEXT OF ENGLISH ABSTRACT: The finite element method is applied to find the temperature field of a fir tree blade root assembly, taking due account of the contact heat resistance. The application of finite elements to comply with the boundary condition of the second kind and the superposition of the pieces are discussed. The modified Crank-Nicolson method is used for transient temperature field problems. Finally some calculation examples are shown.

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ORG: All of the Institute of Engineering Thermophysics, Chinese Academy of Sciences

TITLE: "A New Method of Cooling Turbine Vane"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 73-75

TEXT OF ENGLISH ABSTRACT: In this paper the methods of augmentation of convective heat transfer in the cooling channels of the vane with rough surface and formation of the dynamic coating on the airfoil surface in virtue of silicon additives in the fuel are suggested. With these, the turbine inlet gas temperature could be raised to 1600 K when the coolant to gas flow ratio is 0.03 - 0.04.

AUTHOR: None

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TITLE: "Experimental Study of Dynamic Properties and Suitable Organization of Fluidized Bed Combustion Process for Low Grade Solid Fuels"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 76-82

TEXT OF ENGLISH ABSTRACT: In this article the experimental results of the dynamic properties of the combustion process of low grade solid fuels with broad distribution in a fluidized bed are preliminarily investigated. The suitable organization of the fluidized bed burning low grade solid fuels is also discussed.

AUTHOR: YE Jingwei [5509 4842 4885]
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TITLE: "Fuel Vaporizer"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 83-85

TEXT OF ENGLISH ABSTRACT: The function of the fuel vaporizer and its application to the automobile engine are discussed in this paper. For the purpose of improving the quality of fuel evaporation and engine economy, two types of fuel vaporizer are described and the related experimental characteristics are introduced.

AUTHOR: ZHANG Xuyi [1728 4872 4400]

ORG: Qinghua University

TITLE: "Desulfurization with Limestone in Fluidized Bed Combustion"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 86-88

TEXT OF ENGLISH ABSTRACT: Based on theoretical analysis, a concept that the efficiency of sulfur oxide absorption depends directly on the value of the reactive surface layer is proposed by the author. Experimental data correlates well with the theoretical analysis and a correlation describing the absorption process is introduced. By experiments, the weight fractions of the reactive surface layer of the granular limestone with definite diameters to their total weights are determined. It is found that the reactive surface layer of all the limestone granules remaining in the fluidized bed has almost the same thickness. This will enable the choice of the optimum size of limestone granules.

Experiments to improve the absorptivity of the fine limestone granules and the regeneration of used limestone granules are also discussed.

AUTHOR: ZHANG Qingfan [1728 7230 5672]

ORG: Nanjing Aeronautical Institute

TITLE: "Research on the Recirculating Flow Rate in the Wake of the Two-dimensional Flame Stabilizers (under Cold Conditions)"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 89-91

TEXT OF ENGLISH ABSTRACT: According to the turbulent jet theory, this paper presents a physical model for recirculating flow in the wake of the two-dimensional bluff-body flame stabilizers, and deduces a mathematical formula for evaluating flow rate. Through tests under cold conditions, the coefficient in the theoretical formula has been defined. The formula presented in the paper can be used for evaluating the recirculating flow rate of a two-dimensional flame stabilizer under cold conditions, with a blockage ratio of 0.2 - 0.4, and apex angle of 30-60°.

AUTHOR: TIAN Ziping [3944 1311 1627]

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TITLE: "The Effect of Coal Size on the FBC"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 92-94

TEXT OF ENGLISH ABSTRACT: The aerodynamic characteristics of varied sizes of coal in a fluidized bed are analyzed in this paper. The effects of coal size on the FBC's ignition burning process and combustion efficiency are investigated. The FBC mechanism is described from one side.

AUTHOR: CEN Kefa [1478 0668 3127]
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ORG: All of Zhejiang University

TITLE: "Investigation Measurement of Two-dimensional Flow with Application of Thermo-electrical Velocity Probe for Hot Environment"

SOURCE: Beijing GONGCHENG REWULI XUEBAO [JOURNAL OF ENGINEERING THERMOPHYSICS]
in Chinese Vol 2 No 1, Feb 81 pp 95-97

TEXT OF ENGLISH ABSTRACT: In this article, a revolving hot element with directional shield for quick and automatic measurement of velocity and direction of two-dimensional flow (wind velocity 0-80 m/s, direction 0-360°, temperature 0-400°C) is proposed. A criterion equation for convective heat transmission of the hot element was obtained. The recording time for taking each reading is about 28 seconds. This method and instrument have been used in laboratory tests and on thermo-equipment.

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AUTHOR: ZHENG Changqi [6774 2490 0796]

ORG: Chongqing University

TITLE: "The Calculative Principle of Tooth Surfaces Contact Analysis for Spiral Bevel and Hypoid Gears"

SOURCE: Beijing JIXIE GONGCHENG XUEBAO [CHINESE JOURNAL OF MECHANICAL ENGINEERING] in Chinese No 2, 1981 pp 1-12

TEXT OF ENGLISH ABSTRACT: The calculative analysis for the driving contact process of spiral bevel and hypoid gear tooth surfaces by use of an electronic digital computer is an advanced technique recently derived. It can produce the decisive criterion for collecting the best parameters of gear cutting adjustment and design. M.L. Baxter introduced this method first, and called it "tooth surfaces contact analysis" (TCA).

This paper describes the mathematical procedures in which each item of the formulas of TCA is derived as well as the conjugate action principle of these calculations in any part; it also presents the fundamental formulas to calculate tooth bearing, V-H adjustment values and motion graph.

AUTHOR: WANG Xianshang [3769 0341 0006]

ORG: Chengdu Farm Machinery College

TITLE: "The Checking of the Dynamic Characteristics of Machine Tools"

SOURCE: Beijing JIXIE GONGCHENG XUEBAO [CHINESE JOURNAL OF MECHANICAL ENGINEERING] in Chinese No 2, 1981 pp 13-19

TEXT OF ENGLISH ABSTRACT: In accordance with control theory, some critical standards for checking the dynamic characteristics of machine tools are given in this article which involve the stability and its richness, dynamic errors and characteristics of the transient process. The real time method used to check the characteristics of machine tools is also presented. In addition, the relationship between the critical values and structure factors is analyzed.

AUTHOR: LI Chunli [2621 2504 4539]
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ORG: All of Qinghua University

TITLE: "The Investigation of Graphite Morphology and Structure in Cast Iron"

SOURCE: Beijing JIXIE GONGCHENG XUEBAO [CHINESE JOURNAL OF MECHANICAL ENGINEERING]
in Chinese No 2, 1981 pp 20-27

TEXT OF ENGLISH ABSTRACT: The characteristics of the morphology and structure of the typical graphite (flake, spheroidal, vermicular) in cast iron have been investigated with scanning electron microscopy (SEM). The observation on the specimens treated with deep etching and thermal oxidation etching was carried out and results obtained were as follows:

1. The various classes of flake graphite (Classes A, B, C, D) consisted of flakes that were branched and interconnected. Since they belong to the same type of graphite, their growth primarily occurred in the $[10\bar{1}0]$ direction, and was inhibited in the $[0001]$ direction, following in the formation of flake graphite.
2. The spheroidal graphite may be obtained in cast iron treated with commercially pure magnesium, yttrium or cerium as well as industrially nodulizing agents. The formations of the spheroidal graphite in cast iron treated with magnesium were different in that the surface of this graphite was smoother and more rounded than

[Continuation of JIXIE GONGCHENG XUEBAO No 2, 1981 pp 20-27]

that treated with yttrium and cerium. The surface of the spheroidal graphite obtained with the industrially nodulizing agents was intermediate between the two other forms of the graphite.

It was observed in the thermal oxidation etching specimen that there was an annual ring structure in the spheroidal graphite. It was shown that the surface of the spheroidal graphite was of the (0001) plane of the graphite crystalline structure, and its growth was carried out from the center, along the $[0001]$ direction.

3. The vermicular graphite was of an intermediate morphology between the flake and spheroidal. They were connected in the same eutectic cell. The growth mode of the vermicular graphite was intermediate between that of the flake and spheroidal, also.

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TITLE: "The Application of a Cast Cold Working Die Made of Cr12MoV Steel"

SOURCE: Beijing JIXIE GONGCHENG XUEBAO [CHINESE JOURNAL OF MECHANICAL ENGINEERING]
in Chinese No 2, 1981 pp 28-32

TEXT OF ENGLISH ABSTRACT: When preparing cold working dies made of Cr12MoV steel it should usually be repeatedly forged in order to break the eutectic carbide and eliminate its segregation so that homogeneity of mechanical properties can be guaranteed and deformation or rupture can be avoided in heat treatment. A new precision casting process used in the bicycle industry has been developed to prepare cold working dies. It is not necessary to repeatedly forge to break the carbide or to anneal at high temperatures to dissolve it. Since a fine but hard eutectic carbide network is embedded in rather softer sorbite base, its wearability can be improved appreciably. This results in increasing its service life three times.

AUTHOR: CAI Ruixian [5591 4213 6343]
HAN Tongpu [7281 0681 6225]
DING Libo [0002 4409 0130]

ORG: CAI of the Chinese Academy of Sciences; HAN and DING both of the Changchun Machine Tool Plant

TITLE: "A Simplified Strength Calculation Method for Shrunk Disk-drum Type Rotor with Constant Outer Diameter and Analysis of Calculation Results"

SOURCE: Beijing JIXIE GONGCHENG XUEBAO [CHINESE JOURNAL OF MECHANICAL ENGINEERING]
in Chinese No 2, 1981 pp 33-42

TEXT OF ENGLISH ABSTRACT: A simplified strength calculation method for shrunk disk-drum type rotor with constant outer diameter is presented and some typical calculation results are analyzed and summarized. The cause of bending of a gas turbine rotor has been determined by this method, even after long term operation with full rotation speed and full operating loading.

AUTHOR: GAO Yunwen [7559 0061 2429]

ORG: Dalian Railroad College

TITLE: "A Study of Calculating Method of Cutting Angles"

SOURCE: Beijing JIXIE GONGCHENG XUEBAO [CHINESE JOURNAL OF MECHANICAL ENGINEERING]
in Chinese No 2, 1981 pp 43-52

TEXT OF ENGLISH ABSTRACT: The cutting angles on cutting tools are currently divided into stationary and dynamic conditions. The method of a like-state equation and rotations operation for calculating cutting angles are suggested in this paper. Therefore, the formula of three secant plane angles (1-2), (1-4), is reasoned out in the cutting three-side form and a table has been calculated. Then, the conditions are given for use of form two of the above method.

AUTHOR: HUANG Zhen [7806 4176]

ORG: Northeastern Heavy Machinery College

TITLE: "The Method of Successive Approximation of Link Length for the Position Problem of Complex Plane Link Mechanisms"

SOURCE: Beijing JIXIE GONGCHENG XUEBAO [CHINESE JOURNAL OF MECHANICAL ENGINEERING]
in Chinese No 2, 1981 pp 68-76

TEXT OF ENGLISH ABSTRACT: The position analysis of plane mechanisms with many links is one of the most difficult problems in the theory of mechanisms and machines. All known methods of solving this problem are very complicated since we must solve a set of nonlinear or trigonometric equations with many variables. This paper presents a simpler "method of successive approximation of link length" to determine the positions of Assur's three arm group. This method may also be extended to the solution of the more complex groups.

The method is simple and convenient, and the solution to this problem can reach any given accuracy level. Finally, as an example, all 24 positions of a 13-link mechanism with varied construction are obtained by this method on a digital computer.

AUTHOR: WANG Hongjing
et al.

ORG: None

TITLE: "The Conditions for Steady Revolutions of the Diesel Engine and Methods for Controlling Unsteady Revolutions"

SOURCE: Beijing JIXIE GONGCHENG XUEBAO [CHINESE JOURNAL OF MECHANICAL ENGINEERING]
in Chinese No 2, 1981 pp 77-84

TEXT OF ENGLISH ABSTRACT: The problem of unsteady revolutions of the diesel engine is a complicated one. This paper discusses the problem from the point of view of vibration theory. In this paper the equation of motion is established and the equation of judgment of steadiness is also developed. According to these equations, due explanations are given for the reasons for unsteady revolutions, some complex phenomena are analyzed theoretically and some methods for controlling unsteady revolutions are offered. This paper is unusual in its discussion of the problem of unsteady revolutions of diesel engines, hence it is of great value for reference. It is published here as a basis for further discussions.

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ORG: WANG of the Zhenjiang Farm Machinery College

TITLE: "Research on and Application of Laminar Flowmeter"

SOURCE: Beijing JIXIE GONGCHENG XUEBAO [CHINESE JOURNAL OF MECHANICAL ENGINEERING]
in Chinese No 2, 1981 pp 85-96

TEXT OF ENGLISH ABSTRACT: From the analysis of pulsating flow, it is shown that the direct application of a flowmeter to the pulsating fluid flow measurements must meet two conditions, namely, the velocity must be proportional to the measured parameter and the reading of the measured parameter must be the mean value of time. To attain these two conditions, the laminar flowmeter depends on the laminar element, consisting of a number of narrow passages, and the measuring pressure tube with damping element.

The choice of structure types of laminar elements, the design method of the laminar flowmeter and the laminar element process are discussed in detail. The upper limit values of the Reynolds number Re and $Re \frac{d_d}{l}$ (d_d --equivalent diameter, l --the length of the element) are very important parameters for holding the linear relation between the velocity and pressure drop in the measuring range. For establishing the standard characteristics and using the laminar flowmeter more accurately, formulas are necessary.

[Continuation of JIXIE GONGCHENG XUEBAO No 2, 1981 pp 85-96]

The D-100 laminar flowmeter designed by the authors was tested on the 195, 295 and 395 diesel engine test beds. The reading errors of this laminar flowmeter applied directly to measuring the pulsating mean air flow are less than 1~2 percent when compared with the readings by using the plenum camber (damping pressure pulsating box). Therefore, the laminar flowmeter is simple and effective for pulsating mean flow measurements.

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